THE AMERICAN MINERALOGIST

JOURNAL OF THE MINERALOGICAL SOCIETY OF AMERICA

VOL. 15 MAY, 1930 No. 5

# CURTISITE

## A NEW ORGANIC MINERAL FROM SKAGGS SPRINGS, SONOMA COUNTY, CALIFORNIA.

F. E. WRIGHT AND E. T. ALLEN, *Geophysical Laboratory.*

In the hot spring area of the Franciscan formation at Skaggs Springs, inflammable gases are given off in small quantities at one of the surface vents in the sandstone. At this point specks of a greenish yellow mineral were observed by Mr. L. Curtis of Skaggs Springs; he in turn showed them to one of us (Allen) as something unusual. On examination we found its optical properties to be unlike those of any known mineral. Chemical tests showed it to be organic in nature. A detailed examination of its properties has proved the validity of the preliminary conclusions and demonstrated that the mineral is a hydrocarbon of high atomic weight and extremely high melting temperature.

The mineral occurs in small scattered particles, clusters and crystalline aggregates along cracks and porous parts in the pale gray and buff sandstone. It is associated with opaline silica, arsenic sulfide as realgar, and mercuric sulfide as metacinnabarite. The relations indicate that in this series of minerals deposition of the silica began first; that of the curtisite last. The periods of deposition overlapped considerably. Realgar occurs in the usual small prismatic, red to orange-red crystals, 1 to 3 mm. in length and with characteristic optical and other physical properties. The metacinnabarite occurs in small equant grains, 1 mm. or less in diameter and with indications of octahedral faces here and there, grayish black in color and of metallic luster. The metacinnabarite grains are found only sporadically and then in clusters. Both realgar and metacinnabarite are subordinate in amount to curtisite, which in turn is less abundant than the silica. The opaline silica is restricted to crack fillings whereas the other three minerals are in addition scattered through more porous portions of the sandstone itself.

The crystals of curtisite range in size from fine particles of irregular shape to square or six sided flakes, 1 mm. in diameter. Clusters of these flakes are common along cracks in the sandstone and are recognizable both by the color, yellow to pistachio green, and by the perfect basal cleavage which causes the minute cleavage faces to sparkle in the light after the manner of the micas. The luster is vitreous to adamantine. Fracture, conchoidal. Hardness less than 2. Specific gravity, as determined by heavy liquids (Klein's solution) is approximately 1.235 to 1.237.

No individual grains bounded by measurable crystal faces were observed. The crystal system is probably orthorhombic. Cleavage perfect after (001); poor after (100). In transmitted light the color is yellow to yellowish green; pleochroism noticeable, $\gamma$ = yellow; $\beta$ = yellow, $\alpha$ = pale yellow to nearly colorless; absorption, $\gamma \geq \beta > \alpha$. Refractive indices were determined by the immersion method and for sodium light are: $\alpha = 1.557 \pm .001$, $\beta = 1.734 \pm .001$, $\gamma = 2.07$. The optic axial angle, $2V = 83.5°$, was measured directly with an oil immersion objective; the optical character is positive. The dispersion of the optic axes is slight, $2V_p > 2V_v$. The acute bisectrix emerges apparently normal to the cleavage plane (001); the plane of the optic axes is normal to (100). It is possible that the crystal system is monoclinic and that the acute bisectrix is slightly inclined to the cleavage plane; if so the inclination is so slight that it was not detected. Attempts to produce etch figures on (001) were not successful.

In order to obtain adequate amounts of the mineral for chemical analyses, a long series of separations, in part mechanical by heavy liquids, but chiefly chemical by solution in benzol and recrystallization, was made. After repeating the process of recrystallization in benzol 15 times we obtained a product nearly free from contamination by the small amounts of certain dark brown oils that are apparently associated with the mineral in the rock. For these recrystallization experiments, benzol was used in preference to other solvents because of its volatility and the ease with which it is removed. The mineral is only slightly soluble in hot acetone, amylacetate, butylalcohol, petroleum ether; less than one half per cent is dissolved in hot carbon bisulfide, carbon tetrachloride, chloroform, ether; in boiling benzol about one half per cent is dissolved; in boiling toluol, about 1.5 per cent; in xylol, about 2.5

per cent; in hot aniline over 10 per cent. It is also soluble to some extent in pyridine.

For the first chemical analyses made on the natural mineral and on samples that had been recrystallized only once or twice we are indebted to Dr. F. B. LaForge of the Bureau of Chemistry, U. S. Department of Agriculture. At the time the samples were given to Dr. LaForge we did not know of the organic impurities admixed or adsorbed by the curtisite and became aware of them only after he recommended that the curtisite be purified by recrystallization. The effect of the impurities was especially noticeable in the determinations of both melting point and molecular weight. The results of the combustion analyses made by Dr. LaForge are listed in Table 1.

TABLE 1
ANALYSES OF CURTISITE

| No. | Amount taken, grams | Residue, grams | C | H |
|---|---|---|---|---|
| 1 | 0.1073 | None | 92.48 | 5.42 |
| 2 | 0.1111 | None | 92.17 | 4.97 |
| 3 | 0.0917 | .0004 | 92.39 | 5.53 |
| 4 | 0.1307 | .0007 | 92.34 | 5.52 |
| 5 | 0.1560 | .0025 | 91.87 | 5.32 |

Of these samples, Nos. 1 and 2 were crystallized once from pyridine before analysis; Nos. 3 and 4 were recrystallized several times from benzol. No. 5 was the original curtisite separated by heavy solutions from the sandstone and other matrix. This material on heating turned brown and showed no sharp melting point. We noted that with each recrystallization from benzol, the product became lighter in color and showed less tendency to turn brown on heating. It was thus evident that in order to obtain the mineral free from other organic material a series of repeated recrystallizations should be made. For this purpose additional material was kindly collected for us by Mr. Curtis. The samples were crushed and heated in boiling benzol, which dissolved the curtisite and also the impurities. The liquid was nearly colorless but noticeably fluorescent in pale blue tints. It was boiled down until precipitation of the curtisite began. After cooling, the fine flaky precipitate was filtered. This process was then repeated; twelve to fifteen recrystallizations were thus carried through; with each operation an appreciable portion of the material was lost. The final yield was less than two grams of purified substance. With increase in purity the color of the mineral became pale lemon yellow and the benzol solution lost most of its fluorescence.

With this purified material combustion analyses were made by Wright in the laboratory of Dr. M. Phillips of the Color Laboratory of the Department of Agriculture. The results are given in Table 2.

Table 2
Analyses of Purified Curtisite

| No. | Amount taken, grams | Residue, grams | C | H |
|---|---|---|---|---|
| 1 | 0.1238 | 0.0015 | 94.12 | 5.73 |
| 2 | 0.1548 | 0.0023 | 93.70 | 5.41 |

It is evident from these two analyses that the mineral is a hydrocarbon in which the ratio of the carbon atoms is to that of the hydrogen atoms as 4 to 3.

A series of molecular weight determinations was made by the depression of the boiling point method. For results on material recrystallized only once or twice from benzol, we are indebted to Dr. Phillips (see Table 3).

Table 3
Molecular Weight Determinations on Curtisite

| No. | Weight of mineral, grams | Weight of solvent, grams | Depression of Boiling point °C | Molecular weight |
|---|---|---|---|---|
| 1 | 0.0877 | 19.6670 | 0.055 | 211.6 |
| 2 | 0.1128 | 21.2565 | 0.065 | 213.0 |

Determinations made by Wright with purer material, but with aniline as a solvent, yielded the results given in Table 4.

Of these determinations the first two are in good agreement; the last is much lower. Aniline is very hygroscopic and this may account for the lowering of the last value. Unfortunately there was not sufficient material available to make a series of new determinations with xylol or toluol as solvents. The formula $C_{20}H_{15}$ has the molecular weight 255; the formula $C_{24}H_{18}$, the molecular weight 306. From the evidence available it is probable that $C_{24}H_{18}$ represents the composition of the mineral curtisite.

Comparative tests made with the aid of photographic plates showed no trace of radioactivity in this mineral.

The behavior on heating was first determined on the powdered natural mineral. The powder turned dark brown when held for a long time between 275° and 300°C; no definite melting temperature was observed. Heated over an open gas flame in a small glass tube the mineral melts to a clear liquid, but discolors rapidly. Material that has been recrystallized 8 times also turns brown if held for a long time at 300°C. If it is immersed for one minute only, it begins to discolor at 345°C. At 350°C it turns dark brown. At 358°C it melts fairly sharply and discolors rapidly. A preparation of the highest purity (recrystallized 15 times) behaved as follows: At 360°C the sample turned brown but failed to melt within one minute. At 370°C it melted within one-half minute, at the same time turning very black.

TABLE 4
MOLECULAR WEIGHT DETERMINATIONS ON CURTISITE (PURER MATERIAL)

| No. | Weight of mineral, grams | Weight of solvent, grams | Depression of Boiling point °C | Molecular weight |
|---|---|---|---|---|
| 1 | 0.3894 | 23.7700 | 0.181 | 291.4 |
| 2 | 0.3569 | 22.5585 | 0.174 | 292.8 |
| 3 | 0.2085 | 22.5585 | 0.125 | 236.2 |

Heated in a tube, open at both ends, the mineral sublimes readily and is deposited on the cooler walls, away from the heated area, in very thin flakes that scintillate and show beautiful iridescent colors of interference.

# TRANSLATION-GLIDING IN CRYSTALS OF THE NaCl STRUCTURAL TYPE.

M. J. Buerger, *Massachusetts Institute of Technology.*

## ABSTRACT

The translation-gliding elements recorded for various crystals of the NaCl structural type display an unexpected lack of similarity for crystals of the same structure. New experiments indicate that the gliding elements recorded for NaF are incorrect and that hitherto unknown modes of gliding are possible for NaF, NaCl, KCl, KBr, and KI. In addition, NaBr, NaJ and PbTe have been investigated for gliding. All of the NaCl-like crystals, NaF, NaCl, NaBr, NaI, KCl, KBr, KI, PbS and PbTe glide with $T=(001)$, $t=[1\bar{1}0]$. Of these, all but PbS and PbTe also glide with $T=(110)$, $t=[1\bar{1}0]$, as do also high-$NH_4I$, RbCl, and MgO; these are the usual halite gliding elements. The gliding is shown to be dependent on crystal structure; $t$ is determined by rows of nearest like charged ions; $T$ is dependent on ion radius ratio as well as on the polarizabilities of the ions involved. These factors influencing gliding are operative also in all other crystals for which both structural and gliding are sufficiently complete to allow of correlations.

## INTRODUCTION

As early as 1902, Johnsen recognized the desirability of investigating translation-gliding in the simple alkali haloids as a step toward understanding this type of plastic deformation in more complicated crystals. To quote from his paper devoted to an extended investigation of these salts, Johnsen says, in translation:

> "It appears of interest to investigate an entire series of chemically analogous substances for their translation capabilities; the isometric haloid salts of the alkalies are thus especially designated since crystals are, in part, easy to obtain, well cleavable, and besides, translation has already been demonstrated in NaCl and KCl by Mügge. Eventually a relation between gliding elements and structure will become known first of all for isometric substances; here all the relative distances of the lattice points for each of the three possible space lattices are known."[1]

Since these words were written, the structures of all of the simpler substances investigated by Johnsen have become known through the efforts of students of X-rays, but no great interest appears to have been taken in the possible relations of translation-gliding to structure. Perhaps the simplest start on this problem is to investigate the gliding characteristics of a number of crystals having identical structures, differing only in the ions of which they are composed. The NaCl structural type is especially indicated in this research, not only because numerous substances known to translation-glide belong to this type, but because no less than four different sets of gliding elements have been recorded[2] for its various members, namely:

---

[1] A. Johnsen, Biegungen und Translationen: *Neues Jahrbuch f. Min., Geol., u. Pal.*, **1902**, II, p. 145.

| | *t* | *T* |
|---|---|---|
| PbS | $[1\bar{1}0]$ | (001) |
| | [100] | (001) |
| NaF | [001] | (110) |
| NaCl | $[1\bar{1}0]$ | (110) |
| KCl | | |
| KBr | | |
| KI | | |
| RbCl | | |
| High-$NH_4I$ | | |
| MgO | | |

If mode of gliding is regarded as a function of crystal structure, as it must be, the different gliding behaviors of these structurally similar crystals appear to present an anomaly. Since, in several instances, the experimental methods upon which the above tabulated elements are based were not critical, a possible explanation of the anomaly is erroneous data, and it was considered desirable to repeat the investigation of gliding in all but RbCl, high-$NH_4I$ and MgO, as well as to extend the data by investigating PbTe, NaBr and NaI.

It has proved fortunate that some of the earlier work has been repeated, not only because more desirable data have been obtained for some species, but because one error in previously deduced gliding elements (NaF) has been corrected and two entirely new sets of elements established for the NaCl-like alkali haloids.

## THE GLIDING DATA

### Galena

The usual gliding elements of galena, $t=[1\bar{1}0]$, $T=(001)$, have been discussed in a previous paper.[3] The unusual set of elements $t=$

---

[2] See tabulation of data in: M. J. Buerger, Translation-gliding in crystals: *American Mineralogist*, **15**, 1930, p. 64.

[3] M. J. Buerger, The Plastic Deformation of Ore Minerals: Pt. I, *American Mineralogist*, **13**, 1928, pp. 6–11.

$[100], T=(001)$ were advanced by Taricco,[4] and confirmed by Mügge[5] as an explanation of a peculiar percussion figure ("Taricco's figure"). If a sharp needle is gently tapped, as with a pencil, on a broad, very thin, galena cleavage flake, a minute striated hole is produced with edges and striations parallel to the other two cleavages. On the opposite broad cleavage surface arises a corresponding elevation. The mechanism is interpreted as pushing through a set of coaxial square prisms, with faces parallel to (100) and (010), in the direction $[00\bar{1}]$. This gives gliding elements: $T=(100)$, $t=[00\bar{1}]$ or the equivalent $T=(001)$, $t=[100]$.

## ALTAITE

Through the courtesy of Mr. A. C. Abbott, the writer was able to obtain altaite from the 800 ft. level of the Lake Shore Mine, Kirkland Lake, Ontario. It was possible to extract cleavage pieces of about a millimeter's length from the specimens.

It was observed that in attempting to break off cleavage pieces, the desired portion of the mineral became covered with striae parallel to cleavage traces on all cleavage faces, as well as on surfaces of conchoidal fracture, due to easy plastic deformation. Such striae can only result from gliding with elements $T=(001)$, $t=[hk0]$. The indices can be easily evaluated in this case by the pressure figure.

If a cleavage piece is placed upon a somewhat yielding surface, such as a blotter, and a thin needle with a rounded point is pressed against the upper cleavage surface with the force directed normal to this, a shallow, somewhat rounded, four-sided, pyramidal hole or pit is produced about the needle point, and a corresponding identical elevation is raised on the opposite cleavage face below. The sides of the pit have the attitude of pseudo faces $(hhl)$, and thus the border of the pyramid with the cleavage corresponds to four cube-face diagonals. Both pit and elevation are as free from striations as the original cleavage face, consequently only (001) can be the plane of slipping. The border of the pit with the undisturbed cleavage surface, (001), thus marks the folding direction, $f$, as $[110]$. Consequently $t=[1\bar{1}0]$. This pressure figure is identical in origin with Bauer's pressure figure on galena[6] as interpreted by Mügge.[7] Altaite thus behaves precisely as galena, having elements, $T=(001)$, $t=[1\bar{1}0]$, but is much more plastic.

---

[4] Michele Taricco, Solidi di scorrimento nella galena: *Atti della Reale Accademia dei Lincei*, **19**, 1910, pp. 508–511.

[5] O. Mügge, Über Translationen am Phosgenit und Bleiglanz: *Neues Jahrbuch*, **1914**, I, pp. 48–51.

Sufficiently large pieces of altaite were not obtainable to test for Taricco's figure.

## PERICLASE

Mügge[8] embedded periclase crystals in saltpeter within a steel cylinder and found that pressure produced striae on the cube faces only parallel to the cube edge, while on the octahedral faces only normal to a cube-octahedral edge. This places the attitude of the glide plane as $T=(110)$ and gives the glide direction $t=[1\bar{1}0]$.

## SODIUM FLUORIDE

Johnsen[9] experimented with crystals of NaF derived from a water solution of this difficultly soluble and poisonous salt. The crystals were small octahedrons occasionally combined with cubes, having edge lengths of less than 1 millimeter. By pressing (normal to (111)?) there resulted on $\{111\}$, striae parallel to the edge $[(111):(1\bar{1}1)]$, but no optical alteration appeared. Johnsen says:

> "Accordingly $T$ would apparently be either $=\{111\}$ or $\{110\}$.
>
> "On cleavage faces, one obtains from pricks with a fine needle, four, somewhat faded, weakly birefringent striae which radiate from the prick point and run parallel to cleavage traces; $X$ is parallel to their long directions. Since, for piezo-optical phenomena, the directions $[100]$ are axes of isotrophy we must trace back these striae to the friction linked up with translation, and interpret their directions as traces of the plane $T$. Accordingly $T$ is $=\{110\}$. Due to the gliding friction along $T$, the arising deformation allows the vibrations occurring to be regarded as if in the direction $t$; this would only

---

[6] Max Bauer, Beiträge zur Mineralogie; (5) Über das Vorkommen von Gleitflachen am Bleiglanz: *Neues Jahrbuch,* **1882,** I, pp. 138–150.

[7] O. Mügge, Ueber Translationen und verwandte Erscheinungen in Krystallen: *Neues Jahrbuch,* **1898,** I, pp. 123–138.

[8] O. Mügge, Über Translationen am Schwefel, Periklas und Kupferkies und einfache Schiebungen am Bournonit, Pyrargyrit, Kupferglanz und Silberkupferglanz: *Neues Jahrbuch,* **1920,** pp. 29–30.

[9] A. Johnsen, Biegungen und Translationen: *Neues Jahrbuch f. Min., etc.* **1902,** II, pp. 148–149.

perceptibly influence such rays, one of whose vibration directions coincided with *t*, and the other vibration direction of both polarized emerging ray bundles must lie normal to, or parallel with, *t*. Thus there results, then, $t=[001]$."

So far as the writer has been able to determine, the relations between birefringence and translation elements employed by Johnsen do not yield critical results. Both deformed sodium fluoride and deformed sodium chloride do show birefringence, but this is rather irregularly distributed. When $\{100\}$ planes are parallel with nicol directions, an irregular, patchy birefringence appears which gives an indistinct impression of being localized along $\{110\}$ planes, but if $\{110\}$ planes are parallel with nicol directions, the same phenomenon appears to localize itself along $\{100\}$ planes. The optical evidence is confusing and very indistinct, to say the least, and can not be relied upon; the evidence of striation distribution, however, is indisputable and should alone receive consideration.

In the writer's experiments, good crystals were obtained by evaporating a saturated water solution of sodium fluoride in a covered beaker within an autoclave held at 80° ± 2° Centigrade. Crystals between a half millimeter and a half centimeter edge length were easily grown in this manner, the only form appearing being the cube. These displayed pseudo-monocrystallinity, made manifest by the mosaic on crystal faces and cleavage surfaces. All were very weakly birefringent in patches, a characteristic of natural villiaumite.

A series of preliminary tests were first made by pressing cubes in a vise, protected by sheet cork or blotting paper backing. The crystals were pressed parallel to [001], [110] and [111]. Only with pressure in the [001] direction did striae appear, although all cubes showed some traces of plastic deformation in the form of very slight curvature of faces. The crystals pressed parallel to [001] at times displayed faint striae running normal to the pressure direction on the unpressed cube faces. Greater pressure than required to produce these faint striae invariably produced shattering.

Very good results, however, were obtained by embedding crystals in sulfur within a steel cylinder of one centimeter bore. A piston load of 5,000 pounds was first applied to a cube in the [001] direction. This produced two sets of striae on (001) and $(00\bar{1})$ parallel to the cube edges, and one set of striae normal to the pressure direction on (100), (010), $(\bar{1}00)$ and $(0\bar{1}0)$. The (001) and $(00\bar{1})$ faces had taken on a convex curvature near their edges, while the other cube faces had acquired a concave curvature on their respective edges with (001) and (001), as shown in figure 1. The disposition of striae and the curvatures, taken together, indicate a translation $T=(h0l)$, $t=[\bar{l}0h]$.

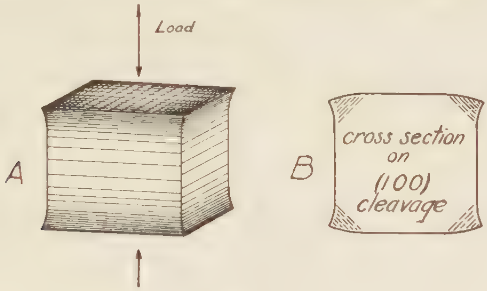

FIG. 1.

In order to confirm this conclusion, another experiment was performed as before, except that the load was applied parallel to [110]. The resulting striae and curvatures are indicated in figure 2.

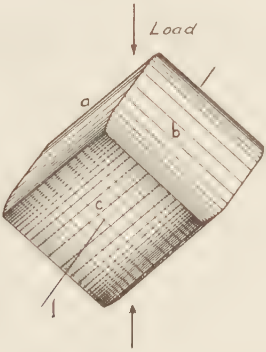

FIG. 2.

The absolute evaluation of $h$ and $l$ necessitates the trace of the glide plane being observed on some form other than the cube. While no determined effort has been made, as yet, to grow crystals with forms other than the cube, it appears quite likely that $h$ and $l$ are each unity from a correlation of curvatures on adjoining cube faces of deformed crystals.

After it had been ascertained that the other, softer, NaCl-like alkali haloids also glide on cube planes (see beyond), an attempt was made to duplicate this behavior in sodium fluoride. A cube was pressed parallel to [110] with the piston load increased to 15,000 pounds. The only striations which appeared were these indicated in figure 2, showing that the greatest part of the deformation took place with gliding elements as above, but there resulted a slight but very distinct alteration of the cube angles after the manner of those shown in figure 3, and new cleavages made slight angles with the deformed cube faces. A further discussion of this effect will be found under sodium chloride. There is thus poor, but reasonable evidence that $T'$ is (100) in sodium fluoride also.

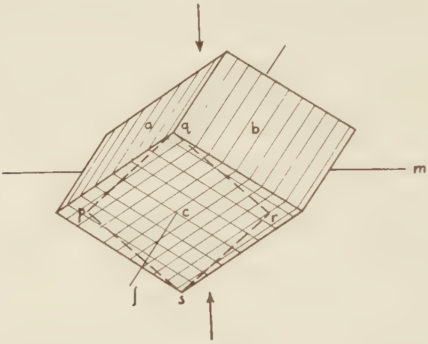

Fig. 3.

## HALITE

Reusch[10] was the first to deduce gliding elements of any sort. He found that by pressing a cleavage piece of halite normal to (001), it showed birefringent sheets making angles of 45° with the pressure direction when examined through (100), (010), $(\bar{1}00)$ or $(0\bar{1}0)$. On these surfaces he also observed striae all of which ran normal to the pressure direction. Thus he concluded that halite deforms in a plastic way by a slipping of $\{101\}$ sheets in $[10\bar{1}]$ directions.

Mügge[11] elaborated on Reusch's research and investigated in some detail the apparent bending of halite cleavage flakes about [001]. Johnsen,[12] working with artificial sodium chloride octahedrons precipitated from a urea-bearing solution, obtained similar translation elements.

---

[10] E. Reusch, Ueber eine besondere Gattung von Durchgängen im Steinsalz und Kalkspath: *Ann. der Physik und Chemie*, **132,** 1867, pp. 443–444, and pp. 449–450.

[11] O. Mügge, Ueber Translationen und verwandte Erscheinungen in Krystallen: *Neues Jahrbuch*, **1898,** I, pp. 138–145.

[12] A. Johnsen, Biegungen und Translationen: *Neues Jahrbuch*, **1902,** II, p. 146.

The writer's experiments were performed both on cleavages of halite from an unknown locality, and on cleavages from artificial cubes precipitated by evaporating a saturated water solution of "C. P." sodium chloride at 80°C. The translation $T=(011)$, $t=[01\bar{1}]$ may be clearly demonstrated as follows: A binocular microscope is focused upon the upper surface of a small cleavage cube. A microscope object glass is then placed on the upper cleavage, tilted slightly about a cube edge, and pressure applied to the object glass (fig. 4), while the process is watched through the glass with the aid of the binoculars. The crystal is sufficiently plastic to flow and make true optical contact with the object glass; meanwhile a portion of the crystal in the vicinity of the cube edge is displaced as shown in figure 4. Due to the ease of flow, pseudo-face *c* is an accurate cast of the glass surface and thus remains striationless. Face *a* is also striationless since this is in the zone *t*, while *b* is quite concave and covered with horizontal striae near the edge *b*:*c*. Looking directly at the face *a*, the disturbed part of the crystal can be seen in profile, and the more or less distinct limit of the disturbance, *rs*, has an approximate slope of 45°. This demonstration that $T$ is (011) and $t$ is $[01\bar{1}]$ is not rigorous, since the same effect would also be brought about by slipping along two planes symmetrically situated about the edge *c*:*b*. Nevertheless, it is the best that can be obtained from the cube form alone, and has been used in obtaining the gliding elements of the other NaCl-like alkali haloids from their cleavage cubes. The method has the advantage over others in that only one set of (011) planes function at once, and thus confusion is avoided.

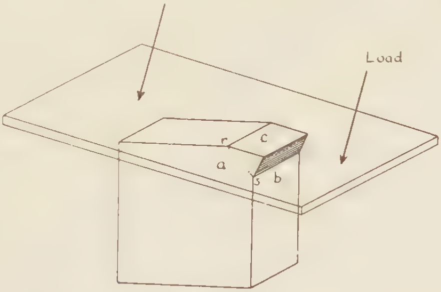

FIG. 4.

Since galena has the same structure as halite, it was thought possible that it also might have gliding elements $T=(011)$, $t=[01\bar{1}]$, as yet unsearched for, as well as its more usual elements $T=(001)$, $t=[1\bar{1}0]$. Tested as above, however, galena shows an inability to glide with the usual halite elements.

On the other hand, these usually quoted gliding elements for halite are not the only ones it may display; there are at least two others. This was discovered in the application of a simple criterion for distinguishing the two sets of gliding elements:

(a) $T=(110)$, $t=[1\bar{1}0]$
(b) $T=(001)$, $t=[1\bar{1}0]$

If a cube is loaded normal to (110), the elements (a) give rise to the striae and shape distortion pictured in figure 2, elements (b) give rise to those of figure 3. Several halite cleavage cubes thus oriented, were embedded in sulfur within steel cylinders and pressure applied. The crystals, however, proved to be so plastic that the individual sulfur grains left their impressions on all previously lustrous cleavage faces and roughened them to such an extent that there was no possibility of discerning the delicate striae. Nevertheless, this important fact was noticed; instead of elongating in the direction $l$, figure 2, as would be expected if (110) alone functions as $T$, the deformed crystal was remarkably elongated in the direction of $m$, figure 3, and of practically the original dimension along $l$. The cube angles were strongly altered, as shown in figure 3. New cleavage surfaces followed along $pq$, $qr$, $rs$, and $sq$, figure 3, at an angle to the attitude of the erstwhile cube surfaces. Now, such a condition can not result from gliding along $\{110\}$ alone with the load as shown, but must result, at least in greater part, from gliding along cube planes if planes of index numbers greater than unity are excluded.

It appeared very desirable to see the actual striations produced by this sort of deformation in order to check this conjecture in a more accurate manner. Since the striations were rendered invisible by reason of the destroyed luster of the faces, a number of very soft embedding media were experimented with, including raw rubber, powdered talc and paraffin, but all these spoiled the originally smooth surfaces. A degree of success was attained by mounting a cleavage cube in concavities between two large cork stoppers. The corks were pressed normal to their surface of joining, within a vise. After removal from the corks it was seen that some parts of the crystal surfaces had not received a heavy load, due to irregularities in the cork. On these spots striae were visible. Striae were disposed as in figure 2, especially near the edges *c*:*a* and *c*:*b*, but away from these on faces *a* and *b* some striae were seen after the manner of distribution shown in figure 3.

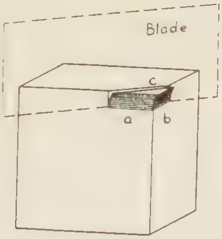

FIG. 5.

The best method of demonstrating translation along cube planes is shown in figure 5. If a razor blade is impressed near the corner of (001) with the blade parallel to (110), it sinks in rather easily, pushing aside the small portion of the crystal shown in the figure.

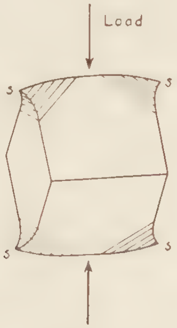

FIG. 6

Striae are absent on *c* but present parallel to the edge *a*:*c* on *a* and the edge *b*:*c* on *b* of the displaced part.

Clearly halite may glide with *T* as (001) and *t* as [*hk*O]. The direction of displacement of the deformed part of the crystal, figure 5, is not a rigorous demonstration that *t* is [110], but is the best that can be obtained from cleavage cubes.

Another set of gliding elements was noticed in the previously mentioned experiments with cork stoppers as an embedding medium and the load parallel to [110]. The four cube corners located with respect to the load as *s*, figure 6, were markedly bent toward the center, and in these regions, rather widely spaced striae parallel to the cube face diagonals could sometimes be made out. Probably this indicated gliding on {111} but the direction and character of the movement are undetermined. Attempts to reproduce this mode of gliding by pressing a corner with a microscope object glass were fruitless, because of confusion with gliding on (110). Apparently it is a phenomenon which only takes place under a relatively great load.

### SODIUM BROMIDE

Water solutions of sodium bromide precipitate the monoclinic sodium bromide dihydrate when evaporated below approximately 50°C.[13] Accordingly, the anhydrous crystals were prepared by slow evaporation of a saturated solution at 80°±2°C using "C. P." sodium bromide as raw material. Crystals a centimeter along an edge or larger could easily be prepared, but these were hollow and irregular, and small perfect pieces had to be cleaved from them for use. The crystals were filtered within the oven, thus preventing hydration. No forms other than the cube were obtained.

Sodium bromide is very sensitive to moisture. In handling it the moisture from the imperceptible perspiration on the hand tarnishes its surfaces. Fresh cleavages must be continually prepared, and cleaving can be accomplished only while the crystal is wrapped in a towel or other protecting envelope.

Sodium bromide behaves like sodium chloride but is more plastic. Tests identical with those mentioned under halite were made, and with the same results, so will not be detailed here.

### SODIUM IODIDE

Like the bromide, sodium iodide crystallizes from a water solution as the dihydrate at ordinary temperatures. Above approximately 65°C the anhydrous salt separates out.[14] Rather tabular, water-clear cubes a centimeter or more long were easily obtained by slowly evaporating the water solution of "C. P." sodium iodide at 80°±2°C. To avoid inversion, the mother liquor was decanted within the oven. Sodium iodide is even more sensitive to moisture than the bromide, and extreme care must be exercised in its manipulation. It is more plastic than the bromide, but otherwise behaves the same.

---

[13] Arthur Messinger Comey and Dorothy A. Hahn, A dictionary of chemical solubilities, inorganic. 2d Ed., *New York*, **1921**, p. 836.

[14] Comey and Hahn, *op. cit.*, p. 854.

### SYLVITE

Mügge[15] states that sylvite behaves in a manner similar to that of halite under pressure, except that translation is somewhat more difficult.

The writer experimented with cleavage cubes of a very homogeneous crystal of sylvite from Stassfurt, as well as with cleavages obtained from cubes precipitated by the evaporation of a saturated solution of C. P. potassium chloride between 80°C and 90°C. These were found to behave precisely as sodium chloride, giving the new gliding elements, as well as those recorded by Mügge. The writer, however, regards potassium chloride as slightly more plastic than sodium chloride, especially with regard to gliding along $T=(001)$.

### POTASSIUM BROMIDE

Johnsen[16] pressed cleavage pieces of commercial potassium bromide, but obtained no visible striations. He claims, however, that with the naked eye, diagonal sheets of varied refractive index appeared through four unpressed cleavages, and that between crossed nicols these sheets showed birefringence. He claims, further, that the percussion figure is the same as for NaCl and KCl. Ritzel[17] also observed birefringent striae under similar conditions.

The writer also experimented with cleavage cubes from coarse crystals of C. P. potassium bromide. The bromide behaves exactly as the chloride, but is much more plastic. It shows a tendency to glide even more easily on cube planes than does sylvite or halite.

### POTASSIUM IODIDE

Johnsen[18] also pressed potassium iodide as he did the bromide, and states that they behave the same. Ritzel[19] reports birefringent striae as seen through (100) and sloping at 45° to the pressure direction when this is normal to (001).

The writer used cleavage cubes of coarse C. P. potassium iodide. It is the most plastic of the alkali haloids personally investigated, and glides in quite the same manner as the bromide.

---

[15] O. Mügge, Über Translationen und verwandte Erscheinungen in Krystallen: *Neues Jahrbuch*, **1898**, I, p. 145.

[16] *Op. cit.*, p. 146.

[17] Albert Ritzel, Translationen und anomale Doppelbrechung bei Steinsalz und Sylvin: *Zeit. f. Krist.*, **52**, 1912–1913, pp. 275–276.

[18] *Op. cit.*, p. 146.

[19] *Op. cit.*, pp. 275–276.

### RUBIDIUM CHLORIDE

Johnsen[20] crystallized RbCl from a water solution and obtained small cubes of about 2 millimeter edge length. Pressed normal to a cube face, all cube faces showed striae parallel to the horizontal edges. A face was ground parallel to (110) on one crystal, and after pressing the crystal normal to (001), this ground face displayed striae parallel to the traces of (101) and (011). This gives: $T=(110)$, $t=[1\bar{1}0]$. Data on gliding along (001) are lacking.

### HIGH-AMMONIUM IODIDE

Johnsen[21] precipitated small cubes of high-$NH_4I$ of about 3 millimeters edge length from a urea-bearing solution. Pressed between cube faces, Johnsen says they behaved as RbCl. Data on gliding along (001) are lacking.

### COLLECTED DATA

The new data obtained, as well as those already recorded, may be summarized in the following form:

| CRYSTAL | Translation-gliding elements | | | Order of Increasing general plasticity and of increasing ease of gliding with $T=(001)$ |
|---|---|---|---|---|
| | $T=(110)$ $t=[1\bar{1}0]$ | $T'=(001)$ $t'=[1\bar{1}0]$ | $T''=(001)$ $t''=[100]$ | |
| NaF | + | + | — | ↓ (Less plastic series) |
| NaCl | + | + | — | |
| NaBr | + | + | — | |
| NaI | + | + | — | |
| KCl | + | + | — | ↓ (More plastic series) |
| KBr | + | + | — | |
| KI | + | + | — | |
| RbCl | + | ? | — | |
| High-$NH_4I$ | + | ? | — | |
| MgO | + | ? | — | |
| PbS | — | + | + | ↓ |
| PbTe | — | + | ? | |

---

[20] *Op .cit.*, p.147.

[21] *Op. cit.*, pp.147–148.

The following points should be noted:

(1) The evaluation of indices of the form (*hk*O) to (110), for the alkali halides, depends, in most cases, on the experiments illustrated in figures 1, 2, 4, and 5, and previously discussed.

(2) Gliding of alkali haloids along (111)? has not, as yet, been sufficiently investigated to warrant inclusion in the table.

(3) No data for gliding on (001) are available for MgO, RbCl and high-$NH_4I$, and the conclusions regarding gliding on (001) for NaF, depend upon shape, not striations.

(4) The absence of gliding with elements $T'' = (001)$, $t'' = [100]$ for the alkali haloids and periclase is deduced from inability to produce the Taricco figure on their cleavage flakes. These crystals yield figures of the halite type.

(5) Haloid for haloid, the sodium salts are less plastic than the corresponding potassium salt.

(6) For both sodium and potassium series, the plasticity, especially gliding with $T' = (001)$, increases from fluoride to iodide.

(7) Altaite is more plastic than galena.

(8) Disregarding the third set of translation elements, $T'' = (001)$, $t'' = [100]$, which has an unusual explanation, the translation direction is $[1\bar{1}0]$ regardless of what plane functions as $T$.

(*To be continued*)

# DUMORTIERITE FROM IMPERIAL COUNTY, CALIFORNIA

John E. Wolff, *Pasadena, California.*

This once rare mineral is now found at an ever increasing number of localities, which are tabulated, with references to their description, and to the mineral in general, in the University of Nevada Bulletin, Vol. XXII, No. 2, issued March 15th, 1928, entitled "On the Mineral Dumortierite," to which the reader is referred. This valuable paper also describes in detail the only mined deposit of commercial value, near Oreana, Nevada, the output of which is used, together with andalusite, in the manufacture of spark plugs, and many hundreds of tons are shipped yearly to Detroit for that purpose.

In California, at least three localities are known by specimens of dumortierite: (1) in Temescal Canyon, Riverside Co., (2) near Dehesa, San Diego Co., and (3) from Imperial Co., in the Colorado desert, with which the specimen here described belongs. From this general locality specimens have come for a long time, but all apparently as loose pieces picked up on the desert, and the locality names usually given merely indicate the nearest settlement, perhaps miles away, such as Ogilby, Calif., 15 miles north-west of the Colorado River; Yuma, Ariz; Picacho, Calif., 20 miles by air line north of Yuma, etc. The parent ledges, so far as known to the writer, have not yet been found, although prospectors have combed the region for this now valuable mineral. In the October number of this Journal (Vol. **14**, pp. 373–381) Eldred D. Wilson described a deposit in place, near Quartzsite, Arizona, some 45 miles North-north east of Clip, Arizona, an old locality name given for the mineral, supposed to have been across the river from Picacho; but since Quartzsite is a long way from the Imperial County locality and separated by the river, it seems hardly possible this could be the original source.

My specimen was obtained from Mr. L. H. Dykes, of Coachella, Calif., now a student of geology at the University of California at Los Angeles. It is a piece of a large boulder, weighing 35 pounds, which he had found in a desert wash some 12 miles north-east of Ogilby and carried on his back a long distance across the desert to his car. Recently he has brought in another boulder of the same size, from the same general locality, 12 inches by 9 by 6, which is beautifully facetted, with a dark brown desert polish on all but the bottom side.

Mr. Dykes has provided the following preliminary notes on the lay of the land, geology, etc., while the writer merely records a cursory study of the first specimen, but expects to go with him to visit the locality, hoping that Mr. Dykes will continue his work in greater detail. That part of the desert, with its lack of roads and water, heat, strong winds and drifting sand, is not exactly a health resort, even in winter, hence when he says in his outline "field-work was limited and only major features were noted," one can sympathize.

Summarizing Mr. Dykes says: The area lies between the Southern Pacific R. R. on the south and the Black Mt. on the north; the Colorado river bounds it on the east and the old Mecca-Blythe road on the west, an area of about 225 sq. miles (See Fig. 1). The Black Mt., south-west from the river, is a low basalt-covered mountain, trending N.W.-S.E., and is about 12 miles long, in places 4 miles wide. The basalt now covers the nearly flat top and the sides with boulders. From the mountain a large alluvial plain slopes south and south-west, its flat surface broken by small volcanic vents at the south end as well as by the Cargo Muchacho Mts., and the plain is cut by numerous desert washes, trending generally with the slope.

Black Mt. is composed mainly of schists, with a gentle dip; these are covered with a basic flow, now remaining as a thick covering of boulders; the lava is fine-grained, and many vents and fissures are found. Not far from the N. W. end of the mountain there are acid massive intrusions, mainly monzonite and granite ("B" Fig. 1), while at the west end are acid effusives ("E" Fig. 1), and shallow dikes and sills, which are probably older than the basalt. The latter perhaps are contemporaneous with that of the Mohave Desert (late Tertiary or younger). There is some evidence of a series of faults along the south-west face of Black Mt., and in the old crystallines on the north side, while in the Cargo Muchacho Mts. torsion and compression are evident in the rocks. These consist of highly folded schists, intruded by medium grained plutonics, while the schists are highly pegmatized in places, and kyanite is found at several localities, especially at the American Girl Mine ("D" Fig. 1), and at the Vitrefrax property, 1½ miles S. W., where the mineral occurs near the contact between schist and plutonic.

The alluvial plain is composed of material washed down from the mountains. Its surface is covered with a mantle of rock fragments and stream-washed materials, the whole composed of plutonics, volcanics, schists and gneisses. A well, now sinking 3 miles N. of Ogilby ("W" Fig. 1), gives some idea of the successive layers down to 91 feet, and corresponds closely to the logs of several shafts sunk on the plain further north.

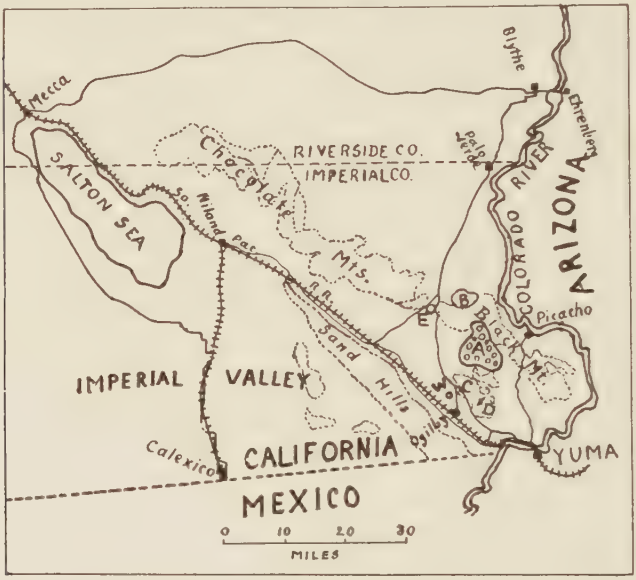

FIG. 1. Orientation Sketch. (A) area of dumortierite boulders; (B) area of acidic intrusives at N. W. corner of Black Mt., mainly monzonite and granite; (C) Cargo Muchacho Mts.; (D) American Girl Mine; (E) area of shallow intrusives and extrusives at W. end of Black Mt., (W) well, 3 miles N. of Ogilby.

From the surface we encounter:

| | |
|---|---|
| 5 ft. | mixture of soil and fragments of schist, granite, quartzite etc. |
| 36″ | red hard pan, (clay, rock fragments, iron oxide). |
| 11 ″ | white volcanic ash (?) -determination uncertain. |
| 2 ″ | "cement rock," a medium to coarse grained pebbly sandstone, cemented by calcium carbonate. |
| 10 ″ | clean washed sand. |
| 20 ″ | sand and round pebbles. |
| 3 ″ | sand and boulders. |
| 4 ″ | "cement rock." |
| — | |
| 91 ″ | |

At about 50 ft. from the surface (apparently near the base of the "volcanic ash") small fragments of the dumortierite rock were brought up.

### DUMORTIERITE

This is found as boulders scattered on the alluvial plain and on the south-west slope of Black Mt., ranging in size from an inch to over two feet in diameter. The center of the area ("A" Fig. 1) lies about 10 miles N. E. from Ogilby, and covers at least 20 sq. miles. There are two types of boulders: (A) those which are well rounded and with desert varnish; (B) which appear to be joint blocks, with little varnish, and have come from stressed rocks. Mr. Dykes thinks this suggests that the dumortierite occurred principally as a large formation, rather than as small isolated patches in the parent rock. Kyanite is found in many specimens and closely resembles that from the American Girl mine and the Vitrefrax property.

So much for Mr. Dykes summary. The writer may add that since prospectors have diligently searched the region for the parent ledges of this striking rock, and so far without success, the ultimate discovery is doubtful, and one can only speculate as to whether the ledges are buried under the plains, or under the basalt cover of Black Mt., or faulted down, or exist at some more distant and unexplored area.

LABORATORY DESCRIPTION OF THE SPECIMEN. The hand specimen is multicolored, the main part is composed of small quartz grains which may be in clear bands but are generally filled with a network of minute dumortierite crystals, which give a dark bluish color to the rock. Thin bands of aggregated prisms of pale green kyanite are intimately associated with the quartz-dumortierite, the two interleaved and interpenetrating, so that the relative age is uncertain. A few minute specks of pyrite are seen. The rock has an indistinct banding and when horizontally broken thin layers are exposed here and there, which consist of minute implanted crystals of a brilliant reddish orange color, determined as rutile, and intimately mixed with adjacent layers. Also thin layers of an orange colored calcite fill irregular cracks, plainly secondary, and perhaps are due to long burial in the wash material and the slow action of percolating moisture, like the "cement rock" mentioned in the well log.

The kyanite does not appear in the thin section used, but was easily determined as such in the powder, as was the rutile. The latter crystals are perfect tetragonal prisms and pyramids, only 0.05 mm. long and 0.02 mm. wide, with a deep brownish red color. They have very high indices and bi-refringence, and are uniaxial positive. Knee-shaped twins were observed and a good titanium test was obtained with a blow-pipe. The quartz aggregate consists of polygonal, equal-sized, interlocking grains, much like a quartzite, but without strain. The clear bands, with but an occasional dumortierite crystal, have larger grains than those rich in that mineral, suggesting some reaction accompanying its formation. Some of the dumortierite crystals are larger than the average, (.09 mm. wide and .8 mm. long), but are mostly in slender long prisms arranged in a net-work through the quartz, without dominant direction individually, but often in bands, sometimes curved in almost a half circle. A rare flake of hematite or rutile may be seen, while small apatite crystals are common in the quartz.

The dumortierite crystals show good cleavages in the zone of the *c* axis and occasional cross fractures perpendicular to *c*. Basal sections, obtained where the rock section has cut through a prism at 90°, have roughly an hexagonal outline, and irregular cracks dividing it into six sectors. Whether this outline is due to twinning according to the aragonite law or merely parallel growth could not be decided owing to the minute diameter of the prisms. The deep blue color parallel to the prism zone is continuous from end to end, but with crossed nicols sometimes varies in the interference color, but this may be due to compensation by other crystals or quartz grains, above or below the one in question.

Optical Characters. These were determined by a combination of methods made necessary because of the minute size of the crystals. The thickness of the section was obtained from several quartz crystals making use of the Universal stage. $\beta$-$\alpha$ was determined upon a large accurately oriented dumortierite crystal and the pleochroism observed with an eye-piece dichroscope. The indices for $\alpha$ and $\beta$ were determined by immersion. On a perfect basal section $H_a$ was found with a fair degree of accuracy by using the ordinary stage and a high power fluorite objective, while $\gamma$-$\beta$ was determined with the compensator. The results are tabulated below.

| | | |
|---|---|---|
| $\beta$ by immersion | 1.687 | |
| $\alpha$ by immersion | 1.668 | |
| $\beta-\alpha$ | 0.019 | |
| $\gamma-\beta$ by compensator and $d$ (thickness) = .023 mm. | 0.001 | |
| $\beta-\alpha$ by compensator and thickness | 0.0188 | |
| The indices are therefore: | | |
| $\gamma$ | 1.688 | ($\beta$ 1.687+$\gamma-\beta$ .001) |
| $\beta$ | 1.687 | |
| $\alpha$ | 1.668 | |
| $\gamma-\alpha$ | 0.020 | |
| $2H_a$ (conoscope) | 23° | |
| and 2V (from $\beta=1.687$) | 20½° | |
| 2V from indices (Mallard formula) | 20° | |

Pleochroism, $\parallel c=\alpha$, deep sky blue,
$\perp c=\gamma$ and $\beta$ colorless, at least for a thickness = .023 mm.

From its mineralogical similarities to specimens found in place at many dumortierite localities, this rock also is evidently a product of contact metamorphism between schist and acid igneous rocks.

# NOTES AND NEWS

## MINERAL CONCENTRATES OF BEACH SAND

David W. Trainer, Jr., *Cornell University.*

### INTRODUCTION

The purpose of this paper is two fold: (1) to describe in detail the concentrates of heavy minerals, the unconcentrated sand, and the gravel found on the beach of Lake Ontario at Toronto, and (2) to discuss the apparent relation which exists between the specific gravity and size of grains in beach concentrates of heavy minerals.

The three specimens of sand and one of gravel which are described. were collected by Dr. James H. C. Martens from the shore of Lake Ontario, just east of the entrance to Toronto harbor. At this locality, the shore of the Lake is one along which materials are moving constantly, according to Coleman.[1] Coleman has also shown that the cliffs of glacial and interglacial deposits at Scarborough Heights east of Toronto, are receding and furnishing the sands and gravels which make up the beach at Toronto.

Two of the specimens were collected from the dark bands or streaks of heavy minerals concentrated on the beach by the action of the waves. These specimens will be spoken of hereafter as the black opaque (chiefly magnetite and ilmenite) concentrate and the garnet concentrate. The other specimens represent the material which is unconcentrated with respect to heavy minerals or as it might be termed the light portion of the beach sand, and the gravel.

Both the black opaque and the garnet concentrate form thin layers on the beach and at places were seen to grade completely from one to the other. Besides the concentrates collected, Dr. Martens noted a gradational material between the heaviest and lightest specimens, which appeared to be rich in pyroxenes and amphiboles.

### The Beach Material

The magnetite grains were extracted from weighed portions of the sands with an ordinary hand bar magnet. The non- magnetic residues were separated by means of the heavy liquid bromoform (specific gravity, 2.8) in the ordinary manner. Percentage weights of the magnetic portion and the grains having specific gravities greater and less than 2.8 were determined. Permanent mounts in Canada balsam were made of the portions having a specific gravity greater than 2.8. These mounts were studied and grain counts made. The results of these counts and other quantitative data are found in Table I.

Besides the detailed studies of the heavy separates of the different sand specimens, mechanical analyses were made of each of the sands, the results of which are given in Table II.

It should be noted that sample No. 141 is the finest of the three and there is a progressive increase in grain size from sample No. 141 to No. 143.

A microscopic examination of the different sieve separates showed that the garnet grains in the black opaque concentrate, specimen No. 141, were retained with

---

[1] Coleman, A. P., Glacial and Post Glacial Lakes in Ontario: *Univ. of Toronto Studies, Publ. of the Ont. Fisheries Research Lab. No.* **10**, pp. 68–69, Toronto, 1922.

TABLE I

| Sample No. | 141[2] | 142 | 143 |
|---|---|---|---|
| | Percentage Weight | Percentage Weight | Percentage Weight |
| Magnetite | 27.91 | 5.86 | 12 grains in a 10 gram sample. |
| Heavier than 2.8 | 71.61 | 88.2 | 1.1 |
| Lighter than 2.8 | .48 | 5.94 | 98.9 |
| | Grain count percent. | Grain count percent. | Grain count percent. |
| Ilmenite | 66.0 | 3.9 | 2.4 |
| Garnet | 28.0 | 56.0 | 7.5 |
| Zircon | 2.4 | . . . | . . . . |
| Tourmaline | 2.0 | . . . . | . . . . |
| Augite | 1.2 | 4.8 | 15.3 |
| Rutile | . . . . | . . . . | 1.2 |
| Light colored Pyroxene | . . . . | 4.8 | 12.2 |
| Carbonate | . . . . | . . . . | 1 grain |
| Leucoxene | . . . . | 1.6 | 14.6 |
| Hornblende green | . . . . | 27.0 | 45.7 |
| Hornblende brown | . . . . | . . . . | 1.2 |
| Monazite | . . . . | 1.6 | . . . |
| Plagioclase | 0.6 | . . . | . . . . |

few exceptions on the 70 mesh sieve. The black opaque minerals (magnetite and ilmenite) made up over 85 percent of the material on the 100, and over 95 percent of that on the 140 and 200 mesh sieves.

TABLE II

| Sample No. | 141 | 142 | 143 |
|---|---|---|---|
| Sieve No. | Percent wt. Retained | Percent wt. Retained | Percent wt. Retained |
| 6 | | . . | . . |
| 12 | . . . . | . . . . | . . . . |
| 20 | trace | trace | trace |
| 40 | 0.08 | 0.74 | 12.24 |
| 70 | 4.86 | 34.72 | 85.26 |
| 100 | 52.58 | 56.44 | 2.28 |
| 140 | 40.46 | 7.14 | . . . . |
| 200 | 1.42 | .20 | . . . . |
| 270 | trace | trace | . . . |
| Pan | . . . . | . . . . | . . . . |
| Total | 99.40 | 99.24 | 99.88 |

---

[2] Number of specimens in the Sedimentary Petrographic Collection at Cornell University, Ithaca, N. Y.

The garnet concentrate, No. 142, showed a similar distribution of the different minerals, except that in this specimen garnet grains constituted about 60 percent of the material on the 70 mesh and 90 percent of that on the 100 mesh sieve. The black opaque constituents made up between 80 and 90 percent of the small amounts on the 140 and 200 mesh sieves. In the latter specimen the hornblende and pyroxene grains were found principally on the 70 mesh sieve.

The heavy grains in the unconcentrated specimen, No. 143, are present in only small amounts and are distributed like those in the heavy concentrates.

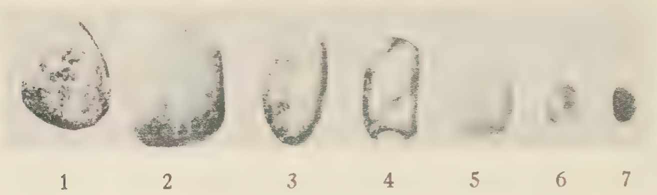

FIGURE I

(1) White to pink quartzite
(2) Gneiss (dark colored)
(3) Dense gray limestone
(4) Orthoclase crystal
(5) Granitic gneiss (light colored)
(6) Vein quartz
(7) Chert (dark colored)

The gravel sample consisted of 100 pebbles representative of those on the beach where the sand samples were collected. The photograph Figure 1. illustrates the several types of pebbles found. Dense gray limestone pebbles similar to No. 3 in the figure made up approximately 65 percent of the sample. The predominance of this type of pebble indicates that their source was rather close at hand. The other pebbles noted and figured, with the exception of the black chert, originated undoubtedly in the rocks of the Laurentian shield.

## SPECIFIC GRAVITY—GRAIN SIZE RELATIONSHIP

The mineral composition of a band or streak of sand formed by the oscillating action of water currents in the superficial layers of a sediment, is apparently dependent upon two factors; the specific gravity and the size of the mineral grains being concentrated. This relationship is well illustrated by the black opaque and garnet concentrates just described. These specimens are characteristic of the bands and streaks ("pay-streaks") encountered in consolidated and unconsolidated sediments, in that they are rich quantitatively in heavy minerals although they are deficient in variety.

It would be extremely difficult with the data at hand to reconstruct a single sand, which would possess the characteristics of the parents of the two heavy concentrates already described. It is very evident though that this hypothetical parent would show a more normal distribution of grain sizes than either of the two concentrates. If now it were possible to follow this parent through the processes of concentration, some general ideas in regard to the way concentration is accomplished might be discovered. All this is impossible, and thus the data at hand concerning the concentrates is interpreted in the light of what is known of sedimentation. An analytical study of the figures given in Table I, shows that 75 percent of the grains of the black opaque concentrate have a specific gravity greater than 4, while only 10 percent of the grains of the garnet concentrate have this high gravity. The mechanical analyses of these sands show that 58 percent of the grains of the black oqaque concentrate were retained on sieves up to and including 100 mesh, while in the garnet concentrate 92 percent of the grains were retained on the same sieves. Some allowance can be made in the case of the garnet concentrate for the extremely light minerals (specific gravity less than 2.8) which were retained on the larger sieves. The microscopic examination of the sieve separates show that the mixing of the garnet and black opaque grains in the two concentrated specimens was not at random but followed a general rule. This rule may be stated as follows: when sand grains are concentrated by wave action, grains of approximately the same specific gravity and size will be found in the same band and where mixing takes place between minerals of varying specific gravity in the same band, the minerals which are deficient in specific gravity will be larger in size.

The rule just stated is based on the principle that a current which is incompetent to carry grains of a given specific gravity and size would be competent to carry grains of a lower specific gravity provided they were of the same size as the first grains. Thus it may be concluded, and the conclusion is borne out by the facts observed in the two concentrates described, that when sand grains of low specific gravity (3–3.5) are mixed in a band or streak with grains of predominately higher specific gravity (5) the grains of lower specific gravity are larger in size. Thus, where the concentration of heavy minerals on beaches has taken place, one would expect to find the minerals of greatest specific gravity at the lowest point on the beach profile succeeded usually with some mixing of grains, up the profile, by concentrates of lower specific gravity and finally by the unconcentrated sand.

---

A teaching fellowship in mineralogy has been established at Stanford University. This fellowship is open to graduate students who intend to specialize in mineralogy and preference will be given to those who have had one year of graduate work. The chief duty of the fellow is to assist in laboratory instruction in mineralogy. Not more than ten hours work a week will be required. The amount of the fellowship is $750, out of which the tuition fee of $300 must be paid.

Application for the year 1930–31, accompanied by testimonial letters, should be made to Professor A. F. Rogers, Box 87, Stanford University, California.

---

Those in charge of the Journal wish to suggest that every effort be made by contributors possessing unfinished articles to complete the manuscripts and send them to the Editor before leaving for summer work. By so doing it is hoped that sufficient material might be accumulated to insure undelayed issues through the summer months.

---

Mr. Samuel G. Gordon of the *Academy of Natural Sciences of Philadelphia* has recently returned from a seven and a half months trip to South America and South Africa. He visited the Bolivian tin deposits and various mines in Southwest Africa, the Union of South Africa, Rhodesia and the Belgian Congo. He collected ninety boxes of specimens including some extraordinary finds of azurite.

# PROCEEDINGS OF SOCIETIES

## NEW YORK MINERALOGICAL CLUB

*Minutes of the February Meeting.*

A regular monthly meeting of the New York Mineralogical Club, attended by 42 persons, was held at the American Museum of Natural History on the evening of February 19, 1930, with President Herbert P. Whitlock in the chair.

A committee was elected to submit nominations for officers at the next meeting. A motion was carried providing that any nominations other than those made by this committee must be submitted prior to the opening of the annual meeting in April.

The speaker of the evening was Mr. O. Ivan Lee, a member of the Club, who discussed "*The Chemistry and Mineralogy of Vanadium.*" After reviewing the interesting history of this element, and its distribution in the mineral, vegetable, and animal kingdoms, he dwelt briefly upon its chemistry and the commercial applications of its alloys and salts.

Mr. Lee classified the vanadium minerals as sulphides (such as patronite), calcium vanadates (such as hewettite), and heavy metal vanadates (such as vanadinite and descloizite). The deposit of patronite at Minasragra, Peru, was described at some length. The gradual exhaustion of this deposit is stimulating the search for other sources of vanadium, and this, in the speaker's opinion, may result in the discovery of new vanadium minerals.

The lecture was illustrated by a large number of specimens of the rarer vanadium minerals, a specimen of the metal, and samples of some of its salts.

Before adjournment an interesting discussion arose, led by Captain Miller, as to whether willemite from any locality other than Franklin, N. J., and northern Rhodesia exhibits fluorescence under ultra-violet light.

HORACE R. BLANK, *Secretary.*

## PHILADELPHIA MINERALOGICAL SOCIETY

*Academy of Natural Sciences, February 6th, 1930.*

A stated meeting of the Philadelphia Mineralogical Society was held on the above date, Mr. Toothaker presiding. Forty-three members and thirteen visitors were present. Dr. Leopold Pessel was nominated for membership. Mr. L. H. Bauer addressed the Society on the "*Minerals of Franklin, New Jersey.*" The speaker presented a brief outline of various theories proposing an explanation of the mineralization of the Franklin district. He further stated that the total number of minerals found at Franklin is now placed at 143, 28 of which occur at no other place. The economic minerals are franklinite, willemite, zincite, calamine and chalcophanite. All the rare and less abundant species, of particular interest to the mineralogist, are included in the waste minerals, the most important of which is calcite which comprises 92% of the tailings. Andradite garnet, rhodonite, micas, feldspar, pyroxene, amphibole, tephroite, hematite, and sphalerite are also frequently found. The composition of the foregoing were described with particular stress on the analytical difficulties connected with their analyses. Among the outstanding difficulties were mentioned the two states of oxidization of iron in franklinite, the separation of water from fluorine and boron in fluoborite, and the separation of aluminum and beryllium in beryllium-vesuvianite.

Various interesting peculiarities and singular properties of many of the minerals were indicated by Mr. Bauer, the more important of which are: Willemite from Sterling Hill is brown while that from Franklin is characteristically green. Calcite which contains a large amount of manganese is white, whereas the brownish calcite has little or no manganese. Franklin actinolite contains 10% ZnO. Specimens of axinite fluoresce in red colors while fluorite shows blue.

An iron arc was used to show the diversity of colors produced by the ultra-violet rays on Franklin minerals. Many choice specimens were exhibited by the speaker supplemented by a number shown by Mr. Toothaker, including one of 98.7% pure zincite, brown, green and a new find of blue willemite. Coxcomb white calamine, blue, black, brown and white calcite, rhodonite, axinite, Be-vesuvianite, a perfect rhombohedral cleavage of hematite and many other choice specimens were placed on exhibition.

The meeting adjourned after giving the speaker a rising vote of thanks.

LESTER W. STROCK, *Secretary.*

## BOOK REVIEWS

INTRODUCTION TO CRYSTAL ANALYSIS. Sir William Bragg. VII+168 pages with 8 plates and 105 figures. D. Van Nostrand Co., Inc., *New York*, 1929. Price $4.25.

Although this book covers much of the same subject matter included in a previous work "*X-rays and Crystal Structure*," the treatment is somewhat different. Originally presented as a series of lectures, there is a more technical approach to the subject. This means, perhaps, less appeal to the general reader, but a correspondingly greater usefulness to the student.

The first two chapters "Reflection by the crystal lattice" and "Methods of analysis" are developed in the usual way. The latter chapter contains a brief description of the rotating crystal method. The chapter on "Simple inorganic compounds" discusses diamond and graphite, fluorite, sphalerite, pyrite, calcite and quartz. In the case of quartz, the $\alpha$ to $\beta$ inversion and one type of twinning are correlated with the structure. Chapter IV, on "Space groups," contains several excellent diagrams illustrating some of the possible symmetrical arrangements of points in space. The crystallographer will look in vain, however, for any recognition of the contribution which his science has made in this field. One would never suspect that the 230 space groups had been completely defined before X-ray analysis had even been dreamed of.

The final chapters are entitled "Complex crystals" and "Metals." They consider very briefly the close-packing of oxygen atoms with reference to silicate structures; a few organic crystals; some common metals and alloys and the development of "fibre" structure through drawing and rolling.

The book is very condensed, and therefore limited in its explanations and examples. However, a sufficient number of typical structures have been included to make it a good summary of the types of problems that have been attacked, and to indicate, to some extent, the tremendous possibilities which lie in the future.

L. S. RAMSDELL

STEREOSCOPIC PHOTOGRAPHS OF CRYSTAL MODELS. F. 582, COMPLETE IN BOX WITH FOLDING STEREOSCOPE. £1.4.9. Adam Hilger, Ltd., 24 Rochester Place, *London*, N. W. 1, England.

This is the second series of 23 stereoscopic photographs of models illustrating the positions of the atoms in the crystalline structures of silicates which have been studied by means of the X-rays. A small descriptive pamphlet edited by Sir William and Professor W. L. Bragg accompanies the photographs.

The visualization of the complex structures of minerals is greatly clarified by this simple device and the folding character of the stereoscope makes it possible to pack both instrument and photographs in a small box, 4 x 5¼ in., which slips readily into a coat pocket.

W. F. H.

GEOLOGISCHE NOMENCLATOR (GEOLOGISCHE NOMENKLATUR, GEOLOGICAL NOMENCLATOR, NOMENCLATEUR GEOLOGIQUE), edited by L. Rutten. 338 pages, diagrams. G. NAEFF, *The Hague*, **1929.** Price $8.50.

This book though of greatest value to the student of general geology, contains however sufficient material to make it likewise of value in a working library in mineralogy and petrology. It is the result of the compilation of geologic words and phrases, in Dutch, German, English, and French, over a period of more than ten years, by members of the "Geologisch-Mijnbouwkindig Genootschap voor Nedreland en Kolonien." The results are published in parallel columns giving the equivalents of Dutch geological words and phrases in German, French, and English. Explanations of terms are in Dutch. At the end of the book are indices in the four languages enabling the reader to find a desired word in any of the languages mentioned and turn to the page where the translations are given.

The "Nomenclator" is divided into sections with different authors. These are: Exogenic Processes and Physiography, by W. E. Boerman and K. Oestreich; Tectonic Geology, G. A. F. Molengraaff; Volcanology, B. G. Escher; Seismology, G. Van Dijk; Stratigraphy and General Paleontology, P. Kruizinga; Petrology, J. A. Grutterink; Ore Deposits, H. F. Grondijs and C. Schouten; Alphabetical Index by L. Rutten. The section on Petrology is divided into subsections dealing with: Crystals; Constituents of Igneous Rocks; Constituents of Sedimentary Rocks; Constituents of Metamorphic Rocks; Textures; Igneous Rocks; Sedimentary Rocks; Metamorphic Rocks; Structure; Classification; and Some Names of Rocks and Minerals. In the complete section about 500 petrologic and mineralogic terms and words are translated into the four tongues, while the index for the complete volume, in German for example, contains approximately 4,000 words and phrases. The mineralogist and petrologist will find additional useful terms translated in the sections on Ore Deposits and Volcanology.

The book is well printed and bound, the volume being 8 x 11 inches. It deserves a place in the library of any geologist engaged in investigative work involving constant reference to foreign literature.

JOHN T. LONSDALE

SPHÄRISCHE TRIGONOMETRIE FÜR NATURWISSENSCHAFT UND TECHNIK. Franz Raaz. 66 pages and 11 text figures. Published by Theodor Steinkopff, *Dresden*, **1928**. Price 6 RM.

This is a book for the technician who occasionally, must solve a spherical triangle. The mathematics is rigorous but is not an end in itself. In 15 pages, the author derives the necessary formulas and proves that they will work for the general, unrestricted, (Möbius) triangle. He then gives a systematic classification of Euler ($180° < A+B+C < 540°$) triangles with sufficient emphasis on the impossible and ambiguous cases. Standard methods for solving and checking along with helpful hints from a computer's experience are given. The half-angle formulas are derived and examples are given to show how the use of them simplifies the solution of acute-angled triangles.

Applications to astronomy and to mathematical geography are not mentioned. A final chapter of 7 pages shows the application to crystallography. The orientation of any plane of a crystal, *i.e.*, the direction-cosines of its normal, can be mapped as a point on a unit sphere and the relations of intersecting planes can be found from a study of the points representing them. This chapter contains one of the few numerical examples which are worked out to the last digit.

The printing and style are satisfactory but some well-drawn figures have been so reduced that the lettering is indistinct. There is a three-page summary of formulas but no index. A bibliography lists 12 titles, 5 in trigonometry, 3 in astronomy, and 4 in crystallography; none are in English.

Norman Anning

## NEW MINERAL NAMES

### Bismutotantalite

E. J. Wayland and L. J. Spencer: Bismutotantalite, a new mineral from Uganda. *Mineral. Mag.*, **22**, 185–192, 1929.

Name: From its relation to the tantalite group.

Chemical Properties: A tantalate of bismuth, $Bi_2O_3.(Ta, Nb)_2O_5$. Analysis by W. O. R. Wynn gave: $Bi_2O_3$ 52.26, $Ta_2O_5$ 40.12, $Nb_2O_5$ 6.63, MnO 0.12, $(Fe, Al)_2O_3$ 0.11, $SnO_2+Sb_2O_3$ 0.04, ign. loss 0.33, $ZrO_2$ trace, $TiO_2$ trace, $ThO_2$, etc., and $U_3O_8$ not detected. Sum 99.61. A partial analysis is also given. Insoluble in acids.

Crystallographical Properties: Orthorhombic. Habit prismatic. $a = 0.7813$, $c = 1.1363$. Forms $a$ (100), $m$(110), $g$(130), $\delta$(011), $k$(103), $\omega$(133) $x$(141). Parting in three directions observable.

Physical and Optical Properties: Color black, luster sub-metallic. Streak black. Fracture sub-conchoidal. Hd. 5–5½. Sp. Gr. 8.15. Under the microscope, transparent in thin splinters; color smoke gray. Extinction parallel. Biaxial. $n$ high, birefringence 0.1 to 0.15.

Occurrence: Found in rough masses or crystals up to several pounds in weight in a pegmatite at Gamba Hill, 25 miles W. N. W. of Kampala, Uganda.

W. F. Foshag

### Fülöppite

I. de Finály and Sándor Koch: Fülöppite, a new Hungarian mineral of the plagionite-semseyite group. *Mineral. Mag.*, **22**, 179–184, 1929.

Name: In honor of Béla Fülöpp, Hungarian mineral collector.

Chemical Properties: A sulfantimonide: $2PbS. 3Sb_2S_3$. Analysis: S 24.10, Sb 47.50, Pb 28.29, $SiO_2$ 0.09; Sum 100.08. Before the blowpipe readily fusible. On charcoal it gives a yellow and white coating. Melts easily in an open tube yielding sulfur fumes and a deposit of $Sb_2S_3$. Not attacked by concentrated hydrochloric or nitric acid.

Crystallographical Properties: Monoclinic. Habit rhomboidal. $a:b:c=1.1087:1:0.7011$. $\beta=85°15\frac{1}{2}'$. Forms $c(001)$, $a(100)$, $d(\bar{1}01)$, $e(112)$, $p(111)$, $t(\bar{2}23)$ $o(\bar{1}11)$, and $s(\bar{2}21)$.

Physical and Mineragraphical Properties: Color lead gray. Luster bright metallic, sometimes with a steel blue or bronzy tarnish. Streak reddish gray. Fracture uneven. Hardness greater than 2. Negative results with $HNO_3$ (1:1), HCl (1:1), KCn (20%), $FeCl_3$ (20%), and $HgCl_2$ (5%). With KOH (40%) a light brown tarnish is formed after 60 seconds, but rubs off. With aqua regia a brownish yellow tarnish but later a bluish tarnish is developed.

Occurrence: Found on III level, Kereszthegy mine at Nagybánya, Comitat Szatmár (now Baia Mare, Satul-Mare, Roumania) with dark colored sphalerite, quartz, dolomite, sulfur and a mineral referred to as keeleyite.

W. F. F.

## Ameletite

Patrick Marshall: The occurrence of a mineral hitherto unrecognized in the phonolites of Dunedin, New Zealand. *Mineral. Mag.*, **22,** 174–178, 1929.

Name: From the Greek *ameles*, neglected, referring to the fact that it has been overlooked so long.

Chemical Properties: A silicate of sodium and aluminum, $6\ Al_2O_3 \cdot 9\ Na_2O. 12\ SiO_2 \cdot \frac{1}{2}NaCl$. Three analyses (made on soluble portion of the rock) gave: $SiO_2$ 36.67, 36.40, 35.96; $Al_2O_3$ 34.70, 34.70, 34.11; CaO 1.80, 2.49, 2.12; $Na_2O$ 24.18, 24.90, 23.03; $K_2O$ 0.86, 0.96, 0.53; $SO_3$ 0.30; Cl 2.15, 3.15, 1.58. Soluble in acids.

Crystallographical Properties: Hexagonal, sections show rectangular and hexagonal sections. Cleavage parallel to one side of the rectangles, distinct; less distinct in hexagonal sections.

Optical Properties: $n$ very low, birefringence .003. Stains violet with silver nitrate solution.

Occurrence: Found abundantly in trachytoid phonolites of the volcanic region of Dunedin, New Zealand. Also at Taipara, Rarotonga, Cook Islands and Huahine and Raiatea, Society Islands.

W. F. Foshag

## Magnesio-Cronstedtite

Name given to the hypothetical molecule $H_4Mg_2Fe_2^{III}SiO_9$, corresponding to cronstedtite. [A. N. Winchell, *Am. J. Sc.*, **11,** 284, 1926.]

## Magnesium-Orthite

A variety of allanite (orthite) from Norberg, Sweden, containing much magnesia and fluorine, perhaps present as the group $MgF_2$. [P. Geijer, *Sveriges Geol. Unders. Årsbok*, **20,** No. 4, p. 7, 1926.]

### Picrocollite

Name given to a hypothetical molecule $H_4MgSi_3O_8 \cdot 2H_2O$, one of the end members of the pilolite-paligorskite group. [E. S. Simpson, *J. Roy. Soc. Western Australia*, **13**, 43, 1927.]

### Iron-Andradite

The name given to a hypothetical garnet molecule, $3FeO \cdot Fe_2O_3 \cdot 3SiO_2$. [W. Fischer, *Bol. Acad. Nac. Cienc. Argentina*, **28**, p. 153, 1925; *Centr. Min.*, Abt. A., p. 36, **1926**.] Called skiagite by L. L. Fermor. *Records Geol. Surv. India*, **59**, 202, 1926. (*Cf. Am. Mineral.*, Vol. **13**, p. 33, 1928.)

### Lovchorrite

A colloidal glassy variety of rinkolite, named from the locality Lovchorr plateau in the Khibinsky tundra, Kola peninsula, north Russia. [E. M. Bonshtedt, *Bull. Acad. Sci. U.S.S.R.*, [6] **20**, 1181, 1926].

### Rafaelite

A vanadiferous asphaltum (the ash $\frac{1}{4}-\frac{1}{2}\%$, contains 21–44% $V_2O_5$) found in 1890 near San Rafael, Argentina. [A. Windhausen and P. T. Vignau, Informes Preliminares de la Direccion General de Minas, *Geologia e Hidrologia*, Buenos Aires, No. **1**; G. Fester and F. Bertuzzi, *Zs. angew. Chem.*, **38**, 364, 1925.]

J. F. Schairer

### Plaffeiite

A fossil resin from the Flysch at Plaffeien, Switzerland. [Tschirch und Kato, *Mitt. Naturfor. Gesell. Bern*, p. 13, **1925**.]

### Weisbachite

A variety of anglesite from Chile containing $BaSO_4$. Probably the same as hokutolite. [F. Kolbeck in C. F. Plattner's Probierkunst mit dem Lötrohre, 7th edit., *Leipzig*, **1907**, pp. 241, 253; 8th edit., **1927**, pp. 235, 246; K. Hlawatsch, *Ann. Naturhist. Mus. Vienna*, **38**, 19, 1925.]

### Magnetoilmenite-Titanomagnetite

Hexagonal mixed crystals of ilmenite with magnetite are called magnetoilmenite. Cubic mixed crystals of magnetite in ilmenite at the other end of the solid solution series are called titanomagnetite. [P. Ramdohr, *150 Festschr. Bergakad. Clausthal*, p. 324, **1925**, *Neues Jahrb. Min.*, Abt. A, **54**, 345, 1926.]

### Normannite

This is a name left in the manuscript in the Freiberg Collection of minerals by A. Weisbach, for a basic bismuth carbonate $3\ Bi_2O_3 \cdot CO_2$, occurring as brown globular aggregates in the Wolfgang Maasen mine at Neustädtel near Schneeburg, Saxony. [A. Tetzner and F. Edelmann, *Jahrb. Berg.- und Hüttenw. Sachsen*, **100**, A 49–A 72, 1926; **101**, A 70–A 122, 1927.] (The properties and composition of the so called normannite' are identical with those of bismutosphärite, Dana No. 283, *System of Mineralogy*, p. 290, 6th edition, **1892**. Abstr.).

J. F. Schairer

## NOTE

The Nature of Pyromelane. William F. Foshag. *U. S. National Museum.* In the *American Journal of Science*, 2d. series, volume **22**, p. 96, 1856, C. U. Shepard has briefly described as a new mineral species "a titanate of alumina, iron with only traces of glucina and lime" to which he gave the name *pyromelane.* The locality is given as the gold washings of McDowell County, North Carolina. Dana refers this mineral to titanite. A specimen of this mineral in the Roebling Collection of the United States National Museum contains, besides the small angular fragments a few rough crystals of a typical brookite habit like that shown in Dana's No. 4. Measurement of one of these crystals has established its essential identity with brookite and since the other properties attributed to pyromelane are identical with those of brookite, this mineral should be referred to brookite and the name pyromelane dropped.